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Basic Research for "Understanding and Managing Causality of Change in Socio-Technical Systems" II

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1.0 Problem:

Understanding and influencing for change is a central concern of design, commerce and societies. Well-intended interventions often lead to unexpected outcomes with significant implications for health, safety, security and prosperity. While considerable intellectual investment has been directed at quantitative and statistical approaches to understanding causality of socio-cultural system change, the complexity and indeterminate nature of underlying states and often nonlinear dynamics poses significant, if not, intractable measurement, computational, and interpretation challenges. As a result, a scalable and functional understanding of underlying causal dynamics of socio-technical systems that can inform real-world interventions leading to desired outcomes remains elusive. What is needed in order to close the gaps resulting from the limitations of current approaches? In particular, what can be learned about underlying causal dynamics from case-based successes and failures? What are the fundamental constraints and best options for coupling multiple approaches and methodologies to "capture" real world scope, scale and complexity of dynamic events? What are the R&D options likely to push the states-of-the-art of understanding, prediction and intervention in complex socio-technical systems?

2.0 Goals for Research effort:

2.1 To build on the Phase 1 state-of-the-art literature review and the key questions identified as needed to close gaps resulting from the limitations of current approaches to Understanding and managing causality of change in socio-technical systems.

2.2 To design and prepare for an interdisciplinary workshop/forum in which a focused subset of the international thought leaders identified and contacted in Phase I would be invited to develop approaches and solutions to the issues represented in 3.0 below.

2.3 To develop and implement a publication plan to professionally engage key subject matter experts to further develop and contribute their data, theories and ideas for several collaborative peer-reviewed publications.

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14. ABSTRACT
The goals of this project were: (1) To build on the state-of-the-art literature review (conducted in Phase I) and the key questions identified as needed to close gaps resulting from the limitations of current approaches to understanding and managing causality of change in socio-technical systems. (2) To design and prepare for an interdisciplinary workshop/forum in which a focused subset of the international thought leaders identified and contacted in Phase I would be invited to develop approaches and solutions to the issues. (3) To develop and implement a publication plan to professionally engage key subject matter experts to further develop and contribute their data, theories and ideas for several collaborative peer-reviewed publications. Progress toward achieving these goals is summarized.

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Cognition, Human Effectiveness, Information Science

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3.0 **Key issues needed be addressed to close gaps resulting from the limitations of current approaches:** The following summarizes the leading questions identified through the literature review and early discussions with international thought leaders.

- Dynamics & Context

What can be learned from underlying patterns of causal relationships: i.e. tipping points, pinball effects, etc.?

Contrast the nature of causality in the realm of ideas versus the physical world? How could these interact and influence the causality of change in complex socio-technical systems?

How do socio-technical systems evolve and transform?

- What are the drivers and moderators to change and stability?
- What are the underlying causal dynamics that reflect and promote change and how do these vary with scale?
- How are causal dynamics determined by the nature of linkages and architectures of teams, groups, organizations, enterprises, and societies?
- What principles govern event propagation and emergence in socio-technical ecologies?

- Methods & Tools

Closing the gap: How can we overcome the limits of current analytic, empirical and modeling options for characterizing, studying and understanding the etiology and dynamics of change in complex socio-technical systems?

To what extent can multiple approaches be "viably" federated and/or made interoperable to support inferences about current, alternative or possible future states of complex socio-technical systems? This encompasses multiple sources of descriptive and prescriptive data from field work, stories, intelligence, models, surveys, ethnographic and case study analysis

What are the best means for characterizing and understanding the impacts of multi-factorial and/or bi-directional interacting causal chains?

- Contrast causality in the realm of ideas versus the physical world with respect to the methods and tools needed to understand their influence in the context of complex socio-technical systems.
- How can fundamental R&D in behavioral and social sciences provide value to understanding or influencing causality in a complex world?

- Prediction & Influence

Effects of context on the nature of change – how can it be understood, addressed, and realized

- Public vs. private systems
- Products (e.g., airplanes) vs. service (e.g., healthcare)
- Domains, i.e., military, manufacturing, healthcare, power (Smart Grid), etc.

- Design & Intervention:

Can understanding and knowledge of causal dynamics and "influential" contributors be used to affect desired outcomes in terms of design, and re-design?

- What are the implications of causal dynamics & context for design of interventions or transformation of:
  - Cultures
  - Emotions and attitudes
  - Beliefs and ideologies
  - Organizations & enterprises
- To what extent can such interventions promote changes of individual, group, and organizational behaviors?

- Management with Uncertainty

Can understanding and knowledge of causal dynamics and "influential" contributors be used to affect desired outcomes?

In what ways are some people better at perceiving causal relationships, inferring the derivative products of complex influences and interactions and to construct and adaptively execute change strategies to influence outcomes?

What can be learned about causal dynamics and managing complexity from successes & failures in real world interventions and practice?

- Design
- Acquisition
- Human Systems Integration
- Problem solving/Trouble shooting
- Medical practice
- Forensics
- Military "Influence operations"
- Risk analysis & assessment
- Marketing
- Technology forecasting
- Organizational transformation

4.0 **Progress on goals and objectives:**

4.1 International thought leaders were selected to participate in the "causality of change" Workshop and to document their ideas relating to the issues in 3.0 in several archival peer-reviewed publications. Invited participants were surveyed to better determine their disciplinary backgrounds, experience and perspectives on the causality of change Appendix 1). The bios of participants, their survey responses and an integrated summary of survey findings are attached as Appendices 2 & 3 respectively.

4.2 An international inter-disciplinary workshop on "Understanding and Influencing the Causality of Change in Complex Socio-Technical Systems" to address the issues in 3.0 was designed, planned and executed through

the early stages of invitation and logistical implementation. The goals set for this WS were:

4.2.1 To enable a productive collaboration amongst global mult-disciplinary experts with common interests in the causality of change in complex socio-technical systems and

4.2.2 To facilitate dialogue on leading researchable questions that press at the boundaries of understanding and practice in this area.

4.3 The location is planned for Brisbane, Australia on 15-18 February 2011. It will take place in an engaging environment and small group discussion format where participants can easily "mix" and form productive relationships. Representatives from sponsoring agencies (AFOSR and ONR) will also participate which can lead to follow on research opportunities. In all, there will be a limit of 22 funded invitations tendered to a vetted global group of multi-disciplinary participants including researchers, practitioners, graduate students from social and psychological sciences, law, philosophy, physics, enterprise and systems engineering, etc. Most are pretty well known in their respective areas and all have "causal dynamics or reasoning" as an abiding common theme in their work.

4.4 The WS will be structured around 5 (1/2 day) working sessions during which four select discussion groups meet independently around focus questions (TBD) and collectively in plenary to share and advance ideas for going forward. The intent is to facilitate self-organization, energetic interactions and some value outcomes. The first morning will include several lead presentations and each discussion session will begin with a select presentation by a participant aimed at stimulating subsequent discussions.

4.5 The second key goal of the project is to coalesce the expertise and ideas of the collaborators and the collective thinking from the WS into a unique set of references that include (1) a Special Issue International Journal - **Information • Knowledge • Systems *Management*** (see www.IKSMOnline.com) and (2) Edited volume ***Complex Socio-Technical Systems: Understanding and Influencing Causality of Change*** **(**IOS Press: Amsterdam) that contributes value to this area.

4.6 A publications development plan was drafted and sent to participants for comment and approval. As a result, authors subsequently submitted abstracts and outlines for their contributions. The outline for the book publication is attached as Appendix 4.

APPENDIX 1

Causality of Change Workshop Participant Survey:

Please briefly respond **as soon as possible** to the questions below keeping to a **one-page limit for the complete response.**

Name_____ Title/Organization_____

Principal Domain(s) of expertise:_____

Disciplinary Roots & Current disciplinary affiliation _____

Share a brief perspective on how/where the Causality of Change theme maps to your primary research interests:

Please briefly ID one or more research challenges that "causality of change' poses for your area of interest.

Select and provide the full reference citation for several key publications that best represent the vector of your relevant principal research interests (Attach PDFs or Docs)

Appendix 2

BIOSKETCHES & SURVEY RESPONSES

(as of 20 Jan)

"UNDERSTANDING AND INFLUENCING THE CAUSALITY OF CHANGE IN COMPLEX SOCIO-TECHNICAL SYSTEMS"

Brisbane, AUSTRALIA
February 16-18, 2011ß

Jos Aarts

Jos Aarts is a senior research scientist at the Institute of Health Policy and Management and the Department of Medical Informatics of Erasmus University Rotterdam in the Netherlands. He is also a visiting research fellow at the University of Pennsylvania, Philadelphia. His general scientific interest is the impact of information technology on clinical work practices. His current interests are electronic prescribing and decision support systems and impact of health IT on clinical workflow. His PhD thesis was on the implementation of computerized physician order entry systems in Dutch and American hospitals. His research papers on CPOE have appeared in Health Affairs, the Journal of American Medical Informatics Association, the International Journal of Medical Informatics and Methods of Information in Medicine. Dr. Aarts has been a visiting scientist at Oregon Health and Science University, Portland, Ore, and the University of New South Wales and the University of Sydney in Australia. He is chair of Working Group Human and Organizational Factors of Medical Informatics of the European Federation for Medical Informatics. He is chair-elect of AMIA's People and Organizational Issues Working Group. He is on the editorial board of the International Journal of Medical Informatics. Dr. Aarts is chair of the Scientific Program Committee of Medical Informatics Europe 2011, which will be held in Oslo, Norway. aarts@bmg.eur.nl

Primary research interests:

In my research I deal with the question how health IT impacts with clinical work practices and workflow. The impact has often unintended consequences, mostly as result of the fact that health IT is part of complex socio-technical system that is health care. For many years I have focused my attention to electronic prescribing of drugs. The combination of the process of prescribing, health IT and computerized decision support and the organizational context has ever since intrigued me. At the one hand electronic prescribing is seen as a technology that can reduce medical errors, but at the other hand the technology has unintended consequences that can even mitigate the intended reduction. In my publications I have for exampled adopted notions of accident causation to understand the risk of too many reminders and drug interactions alerts. I try to expand my empirical studies to a more generalized understanding how information technologies and health care interact.

Challenges posed by "causality of change'

Challenges are the design of effective electronic prescription systems and health IT systems at large taking into account the cognitive interaction between humans and technology.

Hussein Abbass

Professor Abbass leads the Defence and Security Applications Research Centre at the Australian Defence Force Academy Campus of the University of New South Wales, Australia. He is also a Professor and Chair of Information Technology at the School of Engineering and Information Technology, UNSW@ADFA. His research contributions relate to the design of computational models for complex interactions and socio-technical systems. He has been a leader in applying computational intelligence, modelling, simulation and data analysis to a wide range of problems including air-traffic management, intelligence, defence capability planning, and civil and military transportation systems. He received funding from the ARC, Eurocontrol, Airservices Australia, DSTO, and some companies. Abbass is a fellow of the Australian Computer Society, an associate fellow of the Australian Institute of Management, a senior member of the Institute of Electrical and Electronic Engineering (IEEE), and a member of the Air Traffic Control Association. He is currently an associate editor for the IEEE Transactions on Evolutionary Computation and the IEEE Computational Intelligence Magazine. He is also a member of the editorial board for a number of journals. h.abbass@adfa.edu.au

Primary research interests:
Causality of Change underpins many of my projects as I provided examples in the chapter. Some examples include:

- Automated Story Generation [primarily for strategic scenario generation]
- Interdependent Security Problems
- Network Centric Operations
- Future Air Traffic Management Systems
- Cognitive Engineering including Human-Computer Integration

In all of the above, control and influence are primary objectives. Overcoming many of the research challenges to model and simulate these systems contribute simultaneously to overcoming challenges in causality of change. More details and examples are given in my chapter.

Challenges posed by "causality of change'

- The identification of critical points in a trajectory of events to influence/reshape the trajectory, the time-cost tradeoff and the interaction between different trajectories. This ranges from trajectories of a social system to aircraft trajectories.
- Identification of root causes of specific positive and negative phenomenon in a complex system.
- Vulnerability analysis in complex systems.
- Imitation of a social context.

Rani Lill Anjum

Rani Lill Anjum is Associate Professor of Philosophy at Norwegian University of Life Sciences (UMB) and Project Manager of Causation in Science – An interdisciplinary study of causal processes (CauSci). The project has recruited more than 30 national and international experts as project collaborators from the fields of philosophy, biology, physics, psychology and the social sciences. The aim of the project is to develop a better philosophical understanding of causation in tandem with the sciences. Anjum has co-authored a number of articles on causation with Stephen Mumford and a forthcoming book to be published shortly with Oxford University Press, *Getting Causes from Powers*. The book presents a new theory of causation, focusing on issues such as causal complexity, extreme context- sensitivity and the possibility of prevention. Anjum has held a number of fellowships. Her Doctor Artium was on philosophy of logic and language, focusing on the problem of conditionals. She was then postdoctoral fellow at Universities of Tromsø and Nottingham, working on causation and dispositions. Anjum has published within a wide range of areas, including philosophy of language, philosophy of science, logic, metaphysics and philosophy of education. Some of these publications are addressed to a wider audience than professional philosophers. She has co-edited an interdisciplinary book on the theory of sign language, gathering contributions from various research areas and perspectives (Tegn som Språk, Gyldendal Akademisk 2006).
rani.anjum@umb.no

Primary research interests::
Philosophy of Science and causation in the sciences. I am particularly interested in causation in relation to complexity, context-sensitivity and unpredictable effects.

Challenges posed by "causality of change'
The notion of necessity has deep roots in the philosophical thinking of causation. We have tried to show that because of the extreme context-sensitivity of causation, there is no way the presence of the cause in any way can guarantee the presence of the predicted effect. Any tiny change to the context may alter the predicted outcome. This is not a problem for our theory, but most scientists want predictability and necessity for causation.

David Batten

David joined CSIRO in 1970, his work in that period culminating in a PhD in regional economics and leadership of several regional development projects. In 1986, he moved to a Chair in infrastructure economics at the University of Umeå in Sweden. From 1991–95, he also held the position of Professorial Fellow at the Institute for Futures Studies, a scientific think tank in Stockholm. During his years in Sweden, Dr Batten managed teams exploring the complexities and adaptive management of infrastructure systems involving transport, energy, water, waste and community planning. Since returning to Melbourne in the nineties, he has managed the Australian office of the TEMAPLAN Group, an international consortium of small, scientific consultancy firms specializing in complex systems science for industry and government. He has tackled a wide range of complex systems problems with the aid of computer simulation (e.g. Australia's National Electricity Market Simulator, NEMSIM), and has authored or co-edited ten books (e.g. *Complex Science for a Complex World: Exploring Human Ecosystems with Agents*). In 2002, he was invited back to CSIRO to assist with several "One-CSIRO" activities, and is currently involved in projects funded by CSIRO's Energy Transformed Flagship and its Centre for Complex Systems Science. Also, he is Coordinator of CSIRO's Agent-Based Modelling Working Group and Coordinator of COSNet Theme 5 (Cellular automata, agent-based modelling and simulation). david.batten@csiro.au

Primary research interests:

Influencing complex adaptive systems towards more desirable outcomes and away from less desirable ones requires an understanding of how they develop in time, and what the consequences of events may be, given the system's properties, current state and history. Traditionally, one simply searched for causal relationships between events and their consequent effects. But this is not how causality operates in complex adaptive, interconnected systems? My primary research interests in causality of change lie in the area of complex human ecosystems – i.e. on the causal dynamics of the human mind, the behaviour of human collectives, and their impacts on infrastructural and ecological systems.

Challenges posed by "causality of change'

Why do some people reason using simple, linear causation while others invoke systemic causation? When we learn something new, or change our mind about something, how does it change the structure and function of our brains? Does the mental process of "changing one's mind" correspond physically to the process of switching between attractors in our brain? Would a complex systems perspective, centred e. g. on self-organizing, attractor neural networks, be helpful in ordering our thinking about how internal psychic and neurodynamic processes cause humans to reason and behave in one way or another?

Patrick Beautement

Patrick Beautement (MSc Intelligent Systems, BSc Hons Geology and Geography) is the Research Director of The *abaci* Partnership LLP. He has over 25 years experience of developing and implementing novel, practical solutions for taking advantage of complex opportunities and of creatively using a wide range of approaches, methods and modelling and simulation techniques for addressing complex challenges. Patrick has a successful track record of partnering with commerce, government and world-class researchers in multi-disciplinary contexts and in developing toolsets (for interdisciplinary collaboration) with direct relevance to complexity research. Recent work has involved: carrying a systematic analysis of techniques for decision-making in complex environments; developing and employing a framework for assessing the 'real-world-readiness' of agent-based modelling; examining the practicality of using causal and influence networks for exploring complex multi-agency / multi-stakeholder intervention situations; auditing the UK military's experimentation capability and recommending new strategies for governance, for the provision of a grid for experimentation and a road-map for federated change across the enterprise. He has previously been a DARPA Principal Investigator for a successful international 'coalition interoperability experiment' involving over 30 world-class partners from academia, industry and government over a three-year period.
patrick@abacipartners.co.uk

Primary research interests:

My focus is on articulating the ways in which change can be harnessed purposefully through influencing the underlying 'mechanisms' of change in a pragmatic way, 'on-the-fly', using techniques and terminology accessible to and useable by people working in everyday contexts. To me, key to this is judging the appropriateness of various behaviours, processes, capabilities and so on in relation to contexts as they are changing right now. As the 'Deep Water Horizon' inquiry has shown, pre-defining 'appropriateness' in a manual doesn't work and this case is an unfortunate example of the kind of systemic failure of thinking about causality which has become the norm.

Challenges posed by "causality of change'

I feel that the increasing demand for certainty in communities, enterprises and institutions largely goes unchallenged and the unrealistic expectations that follow lead to unnecessary distress that could be avoided if the givens and realities of the real-world were more honestly acknowledged. By helping to express clearly the degrees of uncertainty and unpredictability in real-life, the Causality of Change Theme can assist professionals and communities formulate and implement, for example, more appropriate policies, strategies, ways-of-working and regulatory regimes. Related to this is the prevalence of 'received wisdom', provided in management courses and even in academic institutions, which promotes reductionist certainty over common-sense realities. This collective group-think is, when applied inappropriately, leading to increasing numbers of rather inevitable problems for humanity. It is unfortunate that the differences between approaches has become polarized, rather than their complementary aspects being embraced. My motivation is doing what I can in the 'excluded middle' to demonstrate measurable, practical benefit from cross-disciplinary collaboration across society.

David Chan

David Chan is currently Professor of Psychology and Deputy Provost at the Singapore Management University. He is also Director of the Behavioural Sciences Institute. Professor Chan's research includes areas in research methods and data analysis with a focus on longitudinal modeling and multilevel issues, as well as personnel selection and adaptation to changes. His works on longitudinal modeling have examined how the different facets of changes over time are related to other issues in I-O psychology. Professor Chan has received several scholarly awards including the Distinguished Early Career Contributions Award, the William Owens Scholarly Achievement Award and the Edwin Ghiselli Award for Innovative Research Design presented by SIOP. In 2000, he was ranked 9th world-wide in the list of Top 100 most published researchers of the 1990's in the top journals of I-O Psychology. As of 2010, his works have been cited more than 1400 times by other scholars in articles published in refereed journals in various disciplines. Professor Chan is Senior Editor of the Asia Pacific Journal of Management, Associate Editor of the Journal of Organizational Behavior, and member on the editorial boards of several journals. He also serves on various National Councils and International Advisory Panels and Boards in and outside Singapore. Professor Chan is an elected Fellow of the International Association of Applied Psychology. His biographical profile is featured in Marquis Who's Who in Asia, Who's Who in America, and Who's Who in the World. davidchan@smu.edu.sg

John Duselis

John Duselis, PhD, is currently a Research Computer Scientist for the Air Force Research Lab in its 711th Human Performance Wing's Human Effectiveness Directorate in Dayton, OH. His multi-disciplinary research team is investigating learning contextually-driven Patterns of Life for detection of anomalous behavior from direct and indirect sensing data feeds. He received his PhD and MS in Information and Computer Science specializing in parallel and distributed computing from the University of California, Irvine, and his BS in Mathematics from Purdue University in West Lafayette, IN. John also serves as a Reserve United States Marine Corps Officer and is a graduate of the Expeditionary Warfare School at the Marine Corps University, was stationed at the Marine Corps Warfighting Lab in Quantico, VA, and has served in Iraq. john.duselis@wpafb.af.mil

Primary research interests:
We are interested in the non-linear underpinnings that occur whenever there is human nature involvement or influence. Our research is currently focused on very quantitative methods, but need to understand and grow research into more cohesive and contextually aware approaches related to causal inference.

Challenges posed by "causality of change'
-The non-linearity and qualitative nature of interventions.
-Predictive capabilities

Ian Freckelton

Ian Freckelton is a Senior Counsel in full-time practice at the Victorian Bar. Much of his advocacy work is in the health law area, involving medical negligence, personal injury, regulatory and disciplinary cases. He is also a Professor of Law, Forensic Medicine and Forensic Psychology at Monash University in Melbourne, Australia and an Adjunct Professor at the National Institute of Public Health and Mental Health Research, Auckland University of Technology in New Zealand. He has been a member of 10 statutory tribunals, including the Mental Health Review Board, the Psychosurgery Review Board, the Medical Practitioners Board, and the Disciplinary Appeals Tribunal in Victoria. He is a member of the Victoria's Coronial Council. Ian is the author of more than 400 peer reviewed articles and chapters and 38 books on a range of subjects including medical law, mental health law, therapeutic jurisprudence, causation, compensation law, coronial law, disciplinary law, expert evidence, criminal law, and policing. The first edition of *Death Investigation and The Coroner's Inquest* (OUP, 2006), written with David Ranson, was short-listed as Australia's scholarly book of the year. He is currently completing books on regulation of health practitioners and on scholarly misconduct. Ian is the Editor of the *Journal of Law and Medicine* and Editor-in-Chief of *Psychiatry, Psychology and Law*. He is on the editorial boards of a number of other journals, including *Family Law in New Zealand*, and the *Australian Journal of Forensic Sciences*. He is the Vice-President of the International Institute of Forensic Studies, the Vice-President of the International Organisation of Mental Health Review Tribunals, the Vice-President of the Australasian Academy of Law and Mental Health, and a Past-President and elected life member of the Australian and New Zealand Association of Psychiatry, Psychology and Law. i.freckelton@vicbar.com.au

Primary research interests:

As a senior counsel at the Bar, causation is fundamental to resolution of a wide cross-section of cases – personal injury, product liability, crime, disciplinary, coronial.

As an academic, distinctions between cause, influence and coincidence as a matter of law are of particular interest to me and arise in many different legal contexts. I teach tort law, criminal law, medical law and evidence to postgraduate law students.

The law in the United Kingdom, Canada and Australia has evolved considerably during the past decade, wrestling with "sine qua non", proximate cause, substantive cause and policy issues relating to cause and effect, especially where multifactorial causation is involved.

Challenges posed by "causality of change'

The law tends to deal in binary concepts by reason of dyadic decisions needing to be made by courts – proved or not proved, whether the cases be criminal, civil or administrative matters. For legal purposes a challenge is to afford justice, especially to plaintiffs in civil matters, without unduly burdening defendants with liability for conduct that at the time it was engaged in could not reasonably have been foreseen as risky or where the outcome cannot be proved on the balance of probabilities to have caused the later status of the plaintiff. Thus, both factual causation and scope of liability issues arise, the latter of which involve questions of often poorly articulated policy in differentiating between influence and cause. Inevitably blameworthiness plays an important role, as do constraints upon what can be proved and what cannot.

Tim Haslett

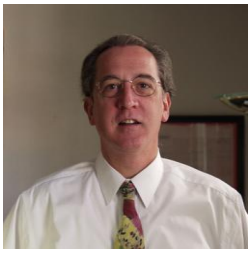
Tim Haslett has over 30 years experience teaching in post-graduate and doctoral Management programs at Monash University including as the Director of the Business Action Research Centre. He has published over 70 refereed conference and journal articles. He currently holds an Adjunct appointment at the University of Queensland. He holds Masters degrees in English Literature, Educational Administration and Business Administration and his PhD is in the business applications of systems modeling and nonlinear dynamics. Dr Haslett's extensive consulting work involves developing systems thinking and computer simulation to support strategic planning. His most recent consulting projects have been with DSTO, Department of Justice, The Alfred Hospital and the Australian Red Cross Blood Service. He also has extensive consulting experience in change management, managing technological change and strategic management. tim@linchpin.org

Primary research interests:
Establishing causation in complex and dynamic business environments and designing interventions for messy problems.

Challenges posed by "causality of change'
Being able to get business people to focus on complex causal issues and make structural changes necessary to affect long-term change.

Being able to explain complex causal relationships, structures and dynamics to people who believe that successful change can be instantaneous and not part of a relatively rigorous learning and testing process

Robert Hoffman



Robert Hoffman is a Senior Research Scientist at the Institute for Human and Machine Cognition in Pensacola FL. Hoffman is recognized as one of the world leaders in the field of cognitive systems engineering and Human-Centered Computing. He is a Fellow of the Association for Psychological Science and a Fulbright Scholar. His Ph.D. is in experimental psychology from the University of Cincinnati, where he received McMicken Scholar, Psi Chi, and Delta Tau Kappa Honors. Following a Postdoctoral Associateship at the Center for Research on Human Learning at the University of Minnesota, Hoffman joined the faculty of the Institute for Advanced Psychological Studies at Adelphi University. He began his career as a psycholinguist, and founded the journal, *Metaphor and Symbol*. His subsequent research leveraged the psycholinguistics background in the study of methods for eliciting the knowledge of domain experts. Hoffman has been recognized internationally in disciplines including psychology, remote sensing, weather forecasting, and artificial intelligence, for his research on human factors in remote sensing, his work in the psychology of expertise and the methodology of cognitive task analysis, and for his work on HCC issues intelligent systems technology and the design of macrocognitive work systems. Hoffman is a Co-Editor for the Department on Human-Centered Computing in *IEEE: Intelligent Systems*. He is Editor for the book Series, "Expertise: Research and Applications." He is a co-founder and Track Editor for the *Journal of Cognitive Engineering and Decision Making.* His major current projects involve evaluating the effectiveness of knowledge management, and performance measurement for macrocognitive work systems. A full vita and all of his publications are available for download at [www.ihmc.us/users/rhoffman/main].
rhoffman@ihmc.us

Primary research interests:
I have been researching specifically the topic of causal reasoning, from a naturalistic perspective, which investigates varieties of causal reasoning in domains of human affairs and professional decision making in sociotechnical systems.

This is causal reasoning about indeterminate causation, closely and necessarily linked to issues of complexity.

Challenges posed by "causality of change'
I interpret "change" with reference to the need for sociotechnical systems to cope with ever-changing and unanticipated situations and challenges.

I interpret "change" with reference to the design of work systems such that the technologies are usable, useful, and understandable, the work is observable, and the work systems are adaptive and resilient.

Matthew Hutchinson

Matthew Hutchinson is a defense contractor for the Air Force Research Lab in the 711th Human Performance Wing's Human Effectiveness Directorate in Dayton, OH. Dr. Hutchinson has worked on several projects for the Air Force focused on IED defeat, new techniques for geospatial ISR data storage, and detecting anomalous behavior from ISR data. He received his PhD, Postgraduate Diploma and BSc from the Department of Spatial Sciences at Curtin University in Perth, Western Australia. His PhD research involved geocoding and agent-based modeling, and his undergraduate education specialized in the fields of Geographic Information Science and Geomatics. Dr. Hutchinson is a former scholarship winner from the U.S Geospatial Intelligence Foundation and former Visiting Scholar at the Department of Geography and Planning at the University of Akron. matt.hutchinson@woolpert.com

Primary research interests:
I would like to better understand the field of "causality" (its theory, frameworks, tools etc.) to assist with establishing what is "normal" and what has "changed" for human behavior in a given setting. Also understanding what the factors were in this change and whether the key factors can be identified and if these can ever be truly verified.

Challenges posed by "causality of change'
Understanding how causality varies depending on culture, for example Western versus European, Asian or Middle-Eastern (to name just a few) cultures. Knowing how "repeatable" the causality factors are in future explanations/situations. Understanding the role of geography in causality of change.

George V. Kondraske

George V. Kondraske, Ph.D. is the founding director of the Human Performance Institute (1986) at the University of Texas at Arlington, where he is professor of electrical engineering and bioengineering. He is also a founding director and CEO of Human Performance Measurement, Inc. His research has been aimed at a quantitative understanding of humans to tasks. This led to development of an array of performance capacity measures and instruments for characterizing human subsystems, many of which are now commercially available, as well as recognition of the need for a theoretical framework for system performance. He subsequently developed General Systems Performance Theory (GSPT) and applied it to the human system to realize the Elemental Resource Model (ERM) for human performance. The thrust of his work involves development of causal performance models that explain the relationship between an individual's profile of basic performance resources and their performance level in complex tasks. This included medical rehabilitation, neurology, ergonomic (e.g., surgery), sports, music, and military contexts. This research has been sponsored by NIDRR, NSF, NASA, DOE, USAF, NIH, the Veterans Administration, as well as private foundations and companies. Kondraske holds appointments at the University of Texas Southwestern Medical Center at Dallas and Texas Woman's University, serves as scientific director for the Center for Music and Medicine at the University of North Texas, and research co-director for the Presbyterian Hospital of Dallas Human Performance Laboratory. He authored over 250 published works on human performance, served as Section Editor for the "Human Performance Engineering" section of *The Biomedical Engineering Handbook* (CRC Press), and holds several U.S. patents. He was awarded the Institute of Electrical and Electronics Engineers (IEEE) "Engineering in Medicine and Biology Society Early Career Award" (1986), the Association for the Advancement of Medical Instrumentation "Becton-Dickinson Career Achievement Award" (1989) and was named a Fellow of the IEEE (2001) "for contributions to the quantitative understanding of human performance through modeling and the development of instrumentation". kondraske@uta.edu

Larry Leifer

Larry Leifer is a Professor of Mechanical Engineering Design and founding Director of the Center for Design Research (CDR) at Stanford University. A member of the faculty since 1976, he teaches the industry sponsored master's course ME310, "Global Project-Based Engineering Design, Innovation, and Development;" a thesis seminar, "Design Theory and Methodology Forum;" and a freshman seminar "Designing the Human Experience." Research themes include: 1) creating collaborative engineering design environments for distributed product innovation teams; 2) instrumentation of that environment for design knowledge capture, indexing, reuse, and performance assessment; and 3), design-for-sustainable-wellbeing. His top development priority in the moment is the Hasso Plattner Design-Thinking-Research Program and associated "Electronic Colloquium on Design Thinking Research," a peer commentary journal. leifer@cdr.stanford.edu

Primary research interests:

The design of products and services is often concerned with changing behavior. The deployment of new tools, systems, and services causes social and individual behavior modification/change. In many cases we start with an intended behavior, for example, "sustainable energy usage" and create tangible artifacts that facilitate, causally, the desired behavior.

In recent research the focus has moved away from the individual and related "human factors" towards the individual's role in a social framework. Using this point-of-view, tools, systems and services are designed to respect and take advantage of "socially correct/desirable" features and functions. In one study we assessed the civility of automated doors. Subjects were asked to assign personality descriptors to various automated door implementations. Imagine that the "door" is a "door man." What do think of this guy? The results showed that people routinely and consistently assign personality to artifacts (ref. Clifford Nass and Byron Reeves work and book, "The Media Equation."

Challenges posed by "causality of change'

Follow on research is looking at the required attributes of physical/tangible remote presence robots that would represent us in distributed collaboration scenarios.

A second line of research looks at the emotional valence of interpersonal exchanges in collaborative work scenarios, e.g., design teams, management teams, sales and support teams. Building on the findings of Jonathan Gottman, we find that the maintenance of a positive emotional atmosphere is causally related to successful collaboration scenarios and that the inverse, a negative emotional atmosphere leads to collapse of open collaboration.

MAY T LIM

May Lim is an Associate Professor of Physics at the University of the Philippines Diliman, and a staff member at the Instrumentation Physics Laboratory where she leads a small team working on complex systems. In 2004-2007, she worked as a postdoctoral fellow at the New England Complex Systems Institute and at Brandeis University, working with Principal Investigator Yaneer Bar-Yam on global pattern formation and on complex networks. may.t.lim@gmail.com

Primary research interests:

My current research interest is the understanding of social systems, either through modeling or data mining. The difficulty in dealing with people-centered systems (e.g. traffic, fisheries) is that the range of responses present to humans in response to 'new rules' to mitigate certain effects may be unexpected by the modeler.

Challenges posed by "causality of change'

Well-intended interventions are rife in traffic systems, often to address the physical constraint of high-volume traffic. Prediction of possible outcomes are challenging – mostly because participants are agents that adapt to new rules. The same challenge with regards to prediction of possible outcomes in response to "new rules" is also present in fisheries.

Michael R. Lissack

CAREER THEME OF initiating innovation and improved best practices in Education-Academics. DBA from Henley, MBA from Yale. Executive Director of ISCE; Project work with Vanderbilt and overseas, including RSM, UVH, University of Technology, Sydney and the Central European University in Budapest. Extensive university references. Lecturer at Williams, Henley, IMD, LSE, Keele, Vanderbilt and Rotterdam School of Management. Endowed two professorial chairs in ethics and management (Williams and UVH). Exceptional leadership and organizational skills – able to create focus and corporate synergy. Visionary but pragmatic: excellent multidisciplinary business acumen, including team building, budget management, and strategic growth planning. Greatest passion – integrating integrity, dignity and innovation as both organizational standards and the internal understanding of professionals. Lissack@lissack.com

Primary research interests:

Human organizations are complex systems in which emotions, beliefs and perceptions are perhaps more important determinants of change than "external events." The twentieth century was dominated by an ever increasing influence of statistics and other forms of efficient representation. To the extent that human systems behave as if they were computer systems, this increase in efficiency leads to increases in prediction, control, and the ability to influence the causal chain for change. To the extent to which humans behave like humans however then little of the preceding sentence is true. Thus the need for the study of qualitative complexity.

Challenges posed by "causality of change'

How does an internal observer/participant of/in a system "know" when the efficacy of a representation is breaking down such that there is a need to revisit broader messages such as stories and compressions? How do unrecognized affordances gain ontic status?

Maris "Buster" McCrabb

Dr. Maris "Buster" McCrabb (Colonel, USAF, retired) is one of the Air Force's foremost experts on the concepts and next-generation technologies needed for effects-based campaign planning, execution and assessment. Prior to retirement, he was the Chief, Force Development and Experimentation Division in the Aerospace Command and Control (C2) Agency. He taught economic warfare and campaign planning at JDACC, ACSC and SAAS. He received a BA from Bowling Green State University, an MS and MPA from Troy University and a DPA from the University of Alabama. A fighter pilot and Fighter Weapons School graduate, he flew combat during the Persian Gulf War where he was detailed as the campaign planner for JTF PROVEN FORCE for which he received the Bronze Star. He has published extensively on the subject including "Is George Bernard Shaw Still Right? Lessons from Coalition Operations" (in *Knowledge-based Planning for Coalition Operations: Symposium Proceedings*, 2004) and essays in *DELIBERATE FORCE: A Case Study in Effective Air Campaigning* (Air University Press, 2000) and *The Paths of Heaven: The Evolution of Airpower Theory* (Air University Press, 1997). Doctor McCrabb is Chief Architect and Founder for DMM Ventures, Inc. a women-owned small business located in Yorktown, VA.. Buster@dmmventure.com

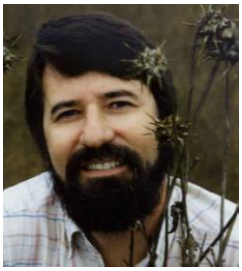
Primary research interests:

Both DMM, a research-oriented firm, and OTT, a development-oriented firm, focus on two related areas: information interoperability and network analysis. Information forms and flows through many interacting nodes and becomes the glue that binds many networks together. Understanding the impacts, or effects, of those flows has occupied our R&D agenda for the past dozen years. In working through those problems, we came to realize that common categories such as causality or inference failed to capture all the dynamics within a network. Further, we came to appreciate the necessity for agglomerated (for now, meaning the spatial or temporal network effects from clustering), or common, structures (or representations) of information that incorporated both physical and non-physical links and nodes. These two insights drew us towards developing and testing a model of network analysis and turning as much of that model as we could into tools useful to analysts facing the challenge of making sense out of such networks. In going beyond strict means of determining causality to a more loosely coupled concept we call dependency, we further realized the resulting uncertainty within the model must be made better apparent to users. In sum, our research interests lie at the nexus of causality & dependency in loosely coupled, semantically consistent, n-dimensional networks that consist of varied nodes physical and social.

Challenges posed by "causality of change".

It is well known that agglomerated networks, regardless of the degree of coupling, pose significant and unique problems relating to aggregation bias. Tying in the inherent uncertainty of virtual networks, like ad hoc social networks, and one rapidly comes face to face with a high order combinatorial problem. This is the most challenging area of network analysis since it goes to the heart of network semantics, which is where the "high payoff" of the semantic web resides.

Patrick McKercher



Patrick McKercher is on the faculty at the University of California Santa Cruz. He did his doctoral work in Rhetoric and Linguistics at the University of British Columbia in Vancouver, Canada. He has extensive outreach experience and worked on integrating digital technology into K-16 education, building computer labs in public schools and creating professional development workshops to train teachers to leverage and explore these resources. In particular, he has researched the educational potential of virtual worlds from time of text-based MUDs/MOOs to the present. He participated in early immersive virtual worlds for education, including the California Virtual High School Project, as well as Virtual UCSC, for which he built eCollegE to teach high school and university students about the environment. In addition, he recruited, trained and managed a cohort of UCSC students to pioneer tutoring and mentoring in VR worlds for the Borderlink project, which provided support to students in under-resourced rural and inner citiy schools. He served on the board of VLearn3D, a consortium of educators and institutions dedicated to developing immersive educational environments, as well as the regional board of AVID (Advancement Via Individual Determination). He frequently presents at education technology conferences such as EARLI, CUE and EdTech. More recently, he has been project manager for James Burke's Knowledge Web (K-Web.org), an open source collaborative and immersive knowledge navigation tool. He has created partnerships with foundations (for example, the Hewlett Foundation Open Knowledge Initiative), public sector digital repositories, and private sector technology companies such as Sun Microsystems and TheBrain Technologies. He is currently researching a book on the technological and cultural ripple effects of world expositions.
pat13@dslextreme.com

Primary research interests:

1) I have been working with James Burke to build his Knowledge Web (k-web.org), a knowledge navigation system that allows the exploration of "small world" social networks of people, events and objects with particular emphasis on technological innovation/diffusion and its social effects.

2) As rhetorician, I have been studying the discourse in the United States regarding climate change, particularly with regard to institutional infrastructure, including government and media. This is the topic for my chapter. My thesis is that conservatives have managed to control the discourse by building and evolving a network of coordinated organizations.

3) College Eight at UCSC has a mission of creating social entrepreneurs to address complex environmental problems. This will require an understanding not only of complex ecosystems, but the economic, social, and political factors that must be accounted for when protecting human and habitat health.

Challenges posed by "causality of change'

The major challenge of investigating the discourse around climate change (itself a "super wicked problem") is interdisciplinary, accounting for the interactions over time of science, government, industry and media/technology

Stephen Mumford

Stephen Mumford, PhD – is Professor of Metaphysics and Head of the School of Humanities at the University of Nottingham, based in the Department of Philosophy. He is author of the books *Dispositions* (Oxford, 1998), *Laws in Nature* (Routledge, 2004), *David Armstrong* (Acumen, 2007) and editor of the books *Russell on Metaphysics* (Routledge, 2003) and George Molnar's posthumous *Powers* (Oxford, 2003). He has authored numerous papers in books and journals. His PhD was from the University of Leeds in 1994 and he held a position there until moving to Nottingham in 1995, where he has remained. From 2004 to 2007 he was Head of the Department of Philosophy and since 2009 has been Head of the School of which Philosophy is a part. Between 2006 and 2010 he was a co-investigator on the AHRC-funded *Metaphysics of Science* project, an interdisciplinary and cross-institutional collaborative project on the philosophical foundations of science. He is currently co-editing a book arising from that project (*Metaphysics and Science*, with Matthew Tugby) as well as a writing a book in philosophy of sport (*Watching Sport: Aesthetics, Ethics and Emotions*, Routledge, forthcoming). In 2006 he began his collaboration with Rani Lill Anjum and together they have completed *Getting Causes from Powers* (Oxford, forthcoming). This develops a new way of thinking about polygenic, complex causation in the real world, rather than merely in limited and finite models. Causes are shown to dispose towards rather than necessitate their effects, which fits with an ontology of powerful particulars. stephen.mumford@nottingham.ac.uk

Primary research interests:

The philosophical explanation of change is my main research area. For almost 20 years I have worked on dispositions, which some people call causal powers. This is a metaphysics that. Among other things, attempts to explain the causality of change. It is also a form of realism about causation, in which it cannot be reduced to anything else but is primitive and basic. There is still, however, much that we can say about it that is informative and illuminating.

Challenges posed by "causality of change'

I am very interested in context-sensitivity of causation because few of the existing philosophical accounts explain it. The understanding of non-linear composition of causes is, I think, related to this.

I would also like the notion of a system to be adequately defined.

Akira Namatame

Prof. Akira Namatame studied Applied Physics at the Japan Defense Academy (NDA) from 1969, graduating with a BS in 1973. He entered the Operations Research program of Stanford University in 1976, graduating MS in 1977. His focus changed slightly for his Ph. D. studies, joining the Department of Engineering - Economic Systems of Stanford University, and graduating in 1979, with a thesis entitled 'Analyses of dynamic competitive systems'. Prof. Namatame joined the Department of Computer Science of NDA in 1988. He is now Academic Dean of the National Defense Academy Graduate School and also a professor of the Department of Computer Science. He has also occupied positions as a visiting Professor at George Mason University (USA) and Chuo University (Japan). Prof. Namatame is well-known as an international research leader in the application of agent and evolutionary modelling technologies to problems in economic and social research, and in the past ten years he has given over 20 invited talks in these areas. His research interests include multi-agent systems, complex networks, evolutionary computation, and game theory. Prof. Namatame is the editor-in-chief of Springer's Journal of Economic Interaction and Coordination. He has published more than 230 refereed scientific papers, together with eight books on multi-agent systems, collective systems and game theory.
nama@nda.ac.jp

Primary research interests:

Social systems including socio-technical systems have emergent properties that cannot be trivially derived from the properties of their components. Unintended consequences and side effects relate closely to emergent properties. In other words, the macroscopic functionality of a system is the sum of the consequences and side effects of emergent properties. In turn, regularities observed at the macroscopic level also influence individual elements. Understanding and shaping emergence may be essential to the survival of social systems. The causality of change theme is one of the main topics for the study of management of social systems with emergent properties.

The study of this bi-directional causal relationship is an essential part of my research.

Challenges posed by "causality of change'

Causality of change can be studied in the same framework of the study of systemic risks. Risks are idiosyncratic –a risk to one system may present an opportunity to another system. Their consequences are harder to predict and present challenges to us all. The qualification of risks lies in their systemic nature and their impacts challenge the integrity of the system. The qualification of risks lies in their causal

relationship. A risk to one subsystem may present an opportunity to another subsystem. A systemic risk is the possibility that an event will trigger a loss of confidence in a substantial portion of the system serious enough to have adverse consequences on system performance, and therefore it impacts the integrity of the whole system.
While quantitative and statistical approaches to understanding systemic risks, the complexity of underlying states pose significant challenges. As a result, understanding of underlying causal dynamics becomes to be essentials as the same as causality of change of socio-technical systems

Steven Sloman

Steven Sloman is a Professor in the Department of Cognitive, Linguistic, and Psychological Sciences at Brown University. He is a computationally-oriented experimental cognitive scientist whose work concerns higher-order aspects of cognition, including causal reasoning and learning, decision making, judgment, and categorization. He received his B.Sc. from the University of Toronto in 1986 and his Ph.D. from Stanford University in 1990. He has published two books, most recently Causal Models: How We Think About the World and Its Alternatives, published by Oxford University Press in 2005. He has also published many research papers and has been on the editorial board of several journals and a number of program committees. He has served as associate editor of the journal Memory and Cognition from 1998-2001 and Cognitive Science from 2005-2006. He is currently an associate editor of the journal Cognition. He has received external grants from NSF, NIMH, NASA, the Templeton Foundation, and Unilever Corporation. His awards include a fellowship from the American Philosophical Society, a Cattell Award, and he was the Distinguished Visiting Scholar in Cognitive Science, University of California, Berkeley, 2009.
Steven_Sloman@Brown.EDU

Primary research interests:
I am interested in how people learn causal models and reason using them. As long as people are involved in initiating or implementing change, it seems necessary to understand how people understand the system they are changing.

Challenges posed by "causality of change'
Most models of causal reasoning have troubling representing cyclic causality, systems that involve loops of cause and effect among the relevant variables. Yet cyclicity is not only common but pervasive. Two questions arise: i. Are human cognitive systems capable of effectively representing such systems and ii. If so, how?

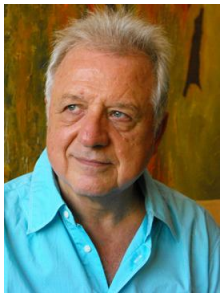
Dave Snowden

Dave Snowden is the founder and chief scientific officer of *Cognitive Edge*. His work is international in nature and covers government and industry looking at complex issues relating to strategy, organisational decision making and decision making. He has pioneered a science-based approach to organisations drawing on anthropology, neuroscience and complex adaptive systems theory. He is a popular and passionate keynote speaker on a range of subjects, and is well known for his pragmatic cynicism and iconoclastic style. He holds visiting Chairs at the Universities of Pretoria and Hong Kong Polytechnic University as well as a visiting fellowship at the University of Warwick. He is a senior fellow at the Institute of Defense and Strategic Studies at Nanyang University and the Civil Service College in Singapore. His paper with Boone on Leadership was the cover article for the Harvard Business Review in November 2007 and also won the Academy of Management aware for the best practitioner paper in the same year. He has previously won a special award from the academy for originality in his work on micro narrative. He is a editorial board member of several academic and practitioner journals in the field of knowledge management and is an Editor in Chief of E:CO. In 2006 he was Director of the EPSRC (UK) research programme on emergence and in 2007 was appointed to an NSF (US) review panel on complexity science research.

He previously worked for IBM where he was a Director of the *Institution for Knowledge Management* and founded the *Cynefin Centre for Organisational Complexity*; during that period he was selected by IBM as one of six "on-demand" thinkers for a world wide advertising campaign. Prior to that he worked in a range of strategic and management roles in the service sector. His company *Cognitive Edge* exists to integrate academic thinking with practice in organisations throughout the world and operates on a network model working with Academics, Government, Commercial Organisations, NGOs and Independent Consultants. He is also the main designer of the SenseMaker® software suite, originally developed in the field of counter terrorism and now being actively deployed in the health sector to handle issues of impact measurement, narrative based knowledge management, strategic

foresight and risk management. dave.snowden@cognitive-edge.com

Constantino Tsallis



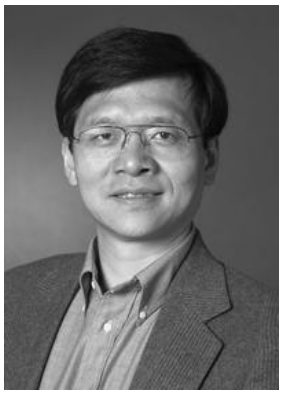
Professor Constantino Tsallis is a physicist in the area of statistical mechanics, head of the Department of Theoretical Physics of the Centro Brasileiro de Pesquisas Fisicas, in Rio de Janeiro (Ministry of Science and Technology of Brazil), and also head of the National Institute of Science and Technology for Complex Systems of Brazil. He obtained his title of Docteur d´ État ès Sciences Physiques from the University of Paris-France in 1974. He has worked in a variety of theoretical subjects in the areas of critical phenomena, chaos and nonlinear dynamics, economics, cognitive psychology, immunology, population evolution, among others. Since two decades, he is focusing on the entropy and the foundations of statistical mechanics, as well as on some of their scientific and technological applications. Indeed, he proposed in 1988 a generalization of Boltzmann-Gibbs entropy and statistical mechanics. This generalization is presently being actively studied around the world: a Bibliography containing more than 3,000 directly related articles, by over 5,000 scientists from 72 countries, is available at http://tsallis.cat.cbpf.br/biblio.htm Prof. Tsallis´ contributions have received over 10,000 ISI citations (over 2,200 of them for his 1988 paper), which currently makes him one among the most cited scientists of all times in Latin America. He has received many international and national distinctions (Guggenheim Foundation Award, Mexico Prize for Science and Technology, Rio de Janeiro Prize of Science and Technology, among many others), and has been given in five occasions the title of Doctor Honoris Causa by Universities from Argentina (Cordoba), Brazil (Maringa and Natal) and Greece (the Thessaloniki Aristotelian University). He is member of the Academy of Sciences of Brazil, as well as of the Academy of Economical, Political and Social Sciences of Brazil. He is main editor of Physica A – Elsevier (Amsterdam), and has supervised close to 40 Doctor and Master Thesis. He has given regular undergraduate and graduate courses in Physics in Brazil, Argentina, USA, France and Germany, and has given over 800 invited

lectures around the world. In 2005 and 2006, he was fully supported by the US Air Force Research Laboratory to do basic research at the Santa Fe Institute, New Mexico, where he co-authored several papers with Murray Gell-Mann, Nobel laureate in Physics due to his prediction of the quarks. Prof. Tsallis is also an external Professor of the Santa Fe Institute.

Primary research interests:
I work in an unifying perspective using the entropy (its nonadditive version, introduced in 1988 in order to generalize Boltzmann-Gibbs statistical mechanics) to deal with complex natural, artificial and social systems. Their nature, characteristics, causes and consequences are of primary interest in my work

Challenges posed by "causality of change'
Strong correlations between the elements of the system, long memory, and hierarchical dynamical/geometrical structures are basic ingredients of complexity. However, the precise necessary and sufficient conditions for using, for a given system, the nonadditive entropy and its associated nonextensive statistical mechanics remain to be established.

Yu Xie



Yu Xie holds several faculty appointments at the University of Michigan. He is Otis Dudley Duncan Distinguished University Professor of Sociology and Statistics and Research Professor in the Survey Research Center and the Population Studies Center, Institute for Social Research (ISR), where he directs the Quantitative Methodology Program (QMP). He is also a Faculty Associate at the Center for Chinese Studies. Professor Xie's main areas of interest are social stratification, demography, statistical methods, and the sociology of science. He recently published Statistical Methods for Categorical Data Analysis with Daniel Powers (Second Edition, Emerald, 2008), Women in Science: Career Processes and Outcomes with Kimberlee Shauman (Harvard University Press, 2003), A Demographic Portrait of Asian Americans (Russell Sage Foundation and Population Reference Bureau 2004) with Kimberly Goyette, and Marriage and Cohabitation (University of Chicago Press 2007) with Arland Thornton and William Axinn. yuxie@umich.edu

Primary research interests:

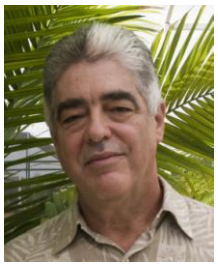
I am interested in heterogeneous treatment effects on social and behavioral outcomes. This workshop will give me an opportunity to interact with researchers in different fields.

Challenges posed by "causality of change'

The real challenge for me is how we can estimate and understand causal effects in the presence of population heterogeneity.

Principals and Sponsors

Kenneth Boff



Kenneth Boff serves as Principal Scientist with the Tennenbaum Institute, Georgia Institute of Technology, Scientific Advisor to the Asian Office of Aerospace Research and Development (Tokyo) and Principal Technologist with Socio-Technical Sciences. From 1997-2007, served as the US Air Force Research Laboratory Chief Scientist for Human Effectiveness. In this position, was responsible for the technical direction of a multi-disciplinary R&D portfolio encompassing individual and organizational behavior, training, protection and the bio and human-engineering of complex systems. He is best known for his work on understanding and remediating problems in the transition of research to applications in the design, acquisition, and deployment of systems and the value-centered management of R&D organizations. Holder of a patent for Rapid Communication Display technology, Boff has authored numerous articles, book chapters and technical papers, and is co-editor of "Organizational Simulation"

(2005) and "System Design" (1987), senior editor of the two-volume "Handbook of Perception and Human Performance" (1986), and the four-volume "Engineering Data Compendium: Human Perception and Performance" (1988). Boff actively consults and provides technical liaison with government agencies, international working groups, universities and professional societies. He has organized and facilitated numerous technical workshops in the US, Europe and the Pacific Rim directed at focusing the expertise of key international thought leaders. He is a Fellow of the Human Factors & Ergonomics Society and the International Ergonomics Association. ken.boff@ti.gatech.edu

Primary research interests:

As a science advisor to the AFOSR and AOARD R&D investment portfolios, I have become increasingly concerned over the likelihood of "payoff" from the massive US investment in understanding and predicting behavioral, social, and cultural influences on outcomes of actions and policies. I prepared the theme of the WS to reflect this concern and to identify alternative strategies and priorities for understanding and influencing causal relations in complex socio-technical systems.

Challenges posed by "causality of change'

- How do socio-technical systems evolve and transform?
- How can we overcome the limits of current analytic, empirical and modeling options for characterizing, studying and understanding the etiology and dynamics of change?
- What are the implications for design of interventions or transformation of:
    - Cultures?
    - Emotions and attitudes?
    - Beliefs and ideologies?
    - Organizations & enterprises?
- What can be learned about causal dynamics and managing complexity from successes & failures in real world interventions and practice?

Robert Bolia

Robert Bolia is Associate Director for Human Factors and Aerospace Sciences at the Office of Naval Research Global–Asia in Tokyo, Japan. He is responsible for building relationships between scientists and program managers in the Naval Research Enterprise and scientists and engineers in the Asia-Pacific region. Previously he served as the chief of the Asia-Pacific Branch of the Air Force Research Laboratory (AFRL) International Technology Office, where he was responsible for building and executing AFRL's international engagement strategy for Asia-Pacific, and for developing collaborative research programs between AFRL and defense laboratories in Australia, India, Japan, Korea, Singapore, and Taiwan. Prior to that he

served as a computer scientist in the AFRL Human Effectiveness Directorate, where he studied decisionmaking, command & control, and advanced technologies to improve situation awareness and team performance in complex environments. Mr. Bolia has authored or co-authored more than 100 book chapters, journal articles, and conference papers on a variety of human factors issues, and is on the editorial board of the journal *Human Factors*. He is also a military historian, has published journal articles on several aspects of modern warfare, and is a frequent book reviewer for *Air & Space Power Journal, Military Review*, *Naval History*, *Naval War College Review*, *Parameters*, and *U.S. Naval Institute Proceedings* . His article on "Over reliance on Technology in Warfare: The Yom Kippur War as a Case Study," published in *Parameters*, was selected for inclusion in the US Army Professional Writing Collection. Mr. Bolia received a B.A. in Mathematics from Wright State University in 1997 and an M.A. in Military Studies (Joint Warfare) from American Military University in 2004. He graduated from Air War College in 2006, and is currently enrolled in Naval War College. He is a member of the Human Factors and Ergonomics Society, the Society for Military History, and the U. S. Naval Institute. In addition, he has a reading knowledge of French, Italian, Russian, and Spanish, and is currently learning Japanese. robert.bolia@onrasia.navy.mil

Primary research interests: I'm not currently engaged in research, but the US Navy is interested in causality/change because it is interested in understanding human and organizational behavior. This applies to a variety of contexts such as appreciating the intentions of enemy forces, recognizing patterns of behavior in populations that may contribute to the development of terrorist networks, etc.

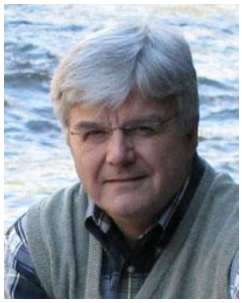
Challenges posed by "causality of change'
Comprehending complex causal relations is useful in the design of decision support systems for military operations at the tactical, operational, and strategic levels. Understanding the cause of a particular action helps dictate the appropriate response. Partly this is due to a lack of appropriate representation of contextual frameworks like common sense in automated reasoning systems, and partly because of inherent uncertainty in the available data (and in reasoning systems able to understand and appreciate uncertainty).

TERENCE LYONS

Terence Lyons is a currently a Program Manager at the Air Force Office of Scientific Research (AFOSR) managing a research portfolio in Socio-Cultural Modeling. Dr. Lyons began his Air Force career in 1976 as a Medical Officer. In his last Air Force assignment (1995-1997) Dr. Lyons was the Commander/Deputy Director of the Armstrong Laboratory, Air Force Materiel Command. In that job he

exercised oversight authority for over 2,150 military, civilian and contractor personnel, with an annual budget of $225 million and $240 million in special purpose facilities. From 1997 until 2000, as an Ass ociate Clinical Professor at Wright State University School of Medicine, he was assigned as a Liaison Officer covering the area of life sciences at the Asian Office of Aerospace Research and Development (AOARD) in Tokyo, Japan - an overseas detachment of AFOSR. From 2001 to 2006 he was the Director of AOARD leading a staff of liaison scientists, administrative officers, and visiting scientists dedicated to assessing emerging technologies and encouraging interaction between AF scientists and research communities in Asia and the Pacific Rim working on leading edge technologies. From 2006 to 2007 Dr. Lyons was the Deputy Chief Scientist of AFOSR advising the Director in planning and integration of AF basic research programs. Dr. Lyons is a Fellow of the American College of Preventive Medicine and the Aerospace Medical Association. He has served as a member of the Advisory Editorial Board of Aviation, Space and Environmental Medicine and has published over 40 peer-reviewed scientific articles, as well as numerous other presentations and publications. From 1995-1997, he was appointed by the Deputy Assistant Secretary of Defense to be the U.S. National Coordinator for the AGARD (NATO) Aerospace Medicine Panel (AMP). terence.lyons@afosr.af.mil

William Rouse



William Rouse is the Executive Director of the Tennenbaum Institute at the Georgia Institute of Technology. He is also a professor in the College of Computing and School of Industrial and Systems Engineering. His research focuses on understanding and managing complex public-private systems such as healthcare and defense, with emphasis on mathematical and computational modeling of these systems for the purpose of policy design and analysis. Rouse has written hundreds of articles and book chapters, and has authored many books, including most recently *People and Organizations: Explorations of Human-Centered Design* (Wiley, 2007), *Essential Challenges of Strategic Management* (Wiley, 2001) and the award-winning *Don't Jump to Solutions* (Jossey-Bass, 1998). He has edited or co-edited numerous books including *Engineering the System of Healthcare Delivery* (IOS Press, 2010), *The Economics of Human Systems Integration* (Wiley, 2010), *Enterprise Transformation: Understanding and Enabling Fundamental Change* (Wiley, 2006), *Organizational Simulation: From Modeling & Simulation to Games & Entertainment* (Wiley, 2005), the best-selling *Handbook of Systems Engineering and Management* (Wiley, 1999, 2009), and the eight-volume series *Human/Technology Interaction in Complex Systems* (Elsevier). Among many advisory roles, he has served as Chair of the Committee on Human Factors of the National Research Council, a member of the U.S. Air Force Scientific Advisory Board, and a member of the DoD Senior Advisory Group on Modeling and Simulation. Rouse is a member of the National Academy of Engineering, as well as a fellow of four professional societies -- Institute of Electrical and Electronics Engineers (IEEE), the International Council on Systems Engineering (INCOSE), the Institute for Operations Research and Management Science (INFORMS), and the Human Factors and Ergonomics Society (HFES). Bill Rouse
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Primary research interests:We focus on enterprise transformation in a range of types of enterprises – global manufacturing, healthcare delivery, energy consumption, and higher education. We try to understand why changes have happened in the past and how to enable changes in the future.

Challenges posed by "causality of change'
None of the enterprises we address can be directly changed in any wholesale way. We have to use our macro understanding to identify tipping points where seemingly small changes, that key stakeholders will embrace, will subsequently precipitate wholesale change. The challenge is identifying such high leverage small changes.

Penelope Sanderson

Professor Sanderson leads the Cognitive Engineering Research Group at The University of Queensland. She is also a Project Leader of a major project on cognitive and organisational systems engineering within National ICT Australia (NICTA), which is Australia's major ICT research and development organisation. Sanderson's principal research contributions relate to the design and evaluation of human-system integration for complex sociotechnical systems. She has been a leader in applying Cognitive Work Analysis (CWA) to the evaluation of human-system integration in air defence domains, and specifically to Australia's Airborne Early Warning and Control platform. More recently, she has led or supervised six major simulator-based studies investigating the effectiveness of novel auditory and visual display design for anesthesia environments, team training for neo-natal resuscitation, and evaluation of distractions in the intensive care unit. In her most recent work with NICTA, Sanderson is developing theories, techniques and tools for prospectively evaluating the impact of new technologies on human-system integration, focusing specifically on major eHealth applications. Sanderson received her PhD from University of Toronto in 1985. While on the faculty of University of Illinois at Urbana-Champaign from 1985 to 1996, Sanderson received research funding from NSF, NASA, the US Department of Energy, and the US Air Force Research Laboratory. Since returning to Australia in 1997 she has received funding from the ARC, DSTO, and Snowy Hydro Ltd, the latter both through contract research and an ARC SPIRT grant. Sanderson is a Fellow of the Academy of the Social Sciences in Australia. In 2004 she was awarded the Distinguished International Colleague Award from the US-based Human Factors and Ergonomics Society (HFES). Sanderson has twice received the HFES Jerome Ely Award (1990 and 2005) for the Best Paper in HFES's peer-reviewed journal, *Human Factors*. She has also won eight best conference paper awards with her students. Sanderson is currently on the editorial boards of *Cognition, Technology, and Work, Journal of Experimental Psychology: Applied, Human Factors* and *Journal of Cognitive Engineering and Decision Making*.

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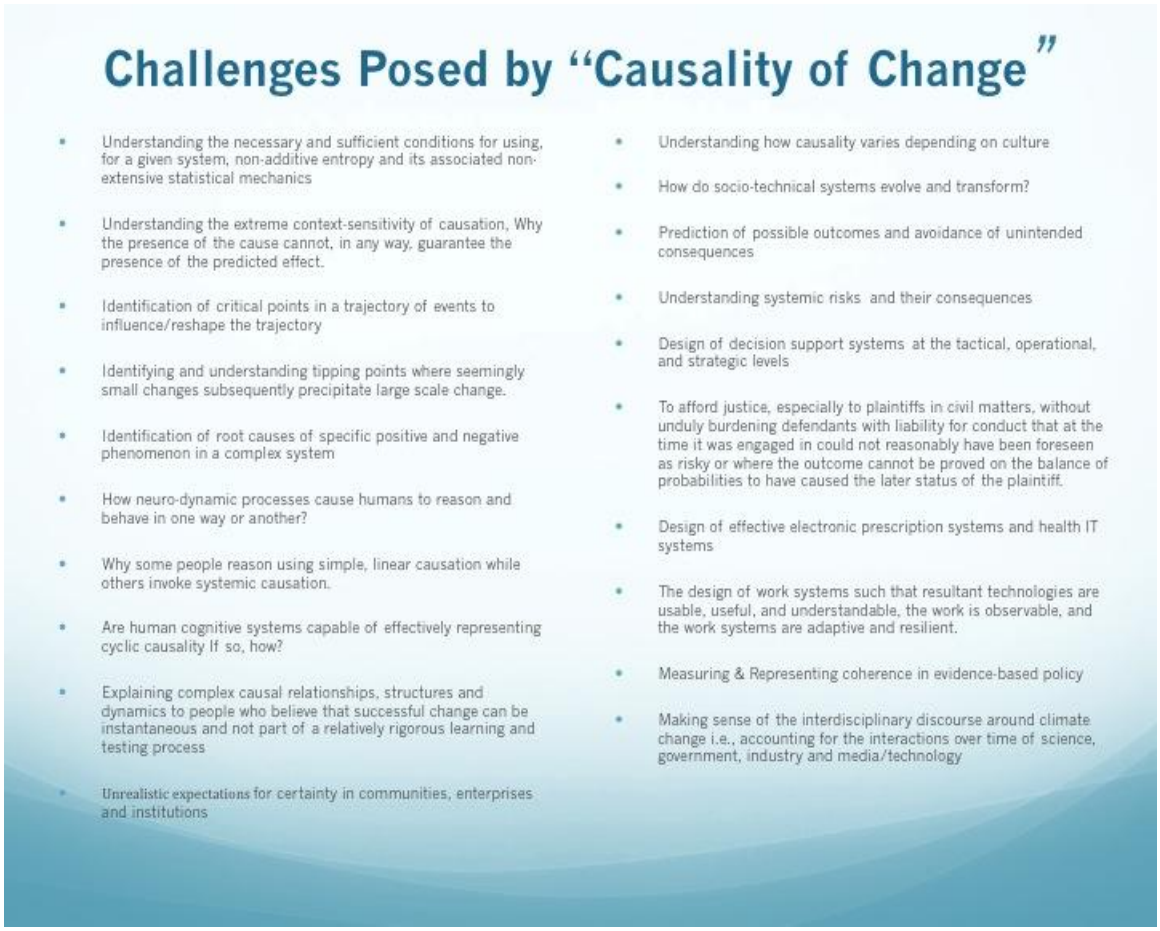
Appendix 3 Participant survey results


Domains of Expertise
Systems Engineering & Design
Human cognitive performance
Modeling & Simulation
Management science
Statistics
Philosophy
Complex networks
IT & Healthcare
Law

Primary Research Interests

- Philosophical explanation of change
- Bi-directional causal relationships
- Understanding social systems
- Emotions, beliefs and perceptions as determinants of change
- Causality & dependency in n-dimensional networks
- Human-Computer Integration
- Understanding causation and predictability in contexts
- Causal reasoning
- Understanding complex natural, artificial and social systems
- Harnessing change in everyday contexts
- Quantitative understanding of influence
- Knowledge management & decision support
- Complex System design and design goals
- Designing interventions in complex socio-technical systems
- Effective Complex Systems applications
- Technological innovation/diffusion and its social effects
- Unintended consequences
- Enterprise transformation


Challenges Posed by "Causality of Change"
Understanding the necessary and sufficient conditions for using, for a given system, non-additive entropy and its associated non-extensive statistical mechanics
Understanding the extreme context-sensitivity of causation, Why the presence of the cause cannot, in any way, guarantee the presence of the predicted effect.
Identification of critical points in a trajectory of events to influence/reshape the trajectory
Identifying and understanding tipping points where seemingly small changes subsequently precipitate large scale change.
Identification of root causes of specific positive and negative phenomenon in a complex system
How neuro-dynamic processes cause humans to reason and behave in one way or another?
Why some people reason using simple, linear causation while others invoke systemic causation.
Are human cognitive systems capable of effectively representing cyclic causality If so, how?
Explaining complex causal relationships, structures and dynamics to people who believe that successful change can be instantaneous and not part of a relatively rigorous learning and testing process
Unrealistic expectations for certainty in communities, enterprises and institutions
Understanding how causality varies depending on culture
How do socio-technical systems evolve and transform?
Prediction of possible outcomes and avoidance of unintended consequences
Understanding systemic risks and their consequences
Design of decision support systems at the tactical, operational, and strategic levels
To afford justice, especially to plaintiffs in civil matters, without unduly burdening defendants with liability for conduct that at the time it was engaged in could not reasonably have been foreseen as risky or where the outcome cannot be proved on the balance of probabilities to have caused the later status of the plaintiff.
Design of effective electronic prescription systems and health IT systems
The design of work systems such that resultant technologies are usable, useful, and understandable, the work is observable, and the work systems are adaptive and resilient.
Measuring & Representing coherence in evidence-based policy
Making sense of the interdisciplinary discourse around climate change i.e., accounting for the interactions over time of science, government, industry and media/technology

Appendix 4

COMPLEX SOCIO-TECHNICAL SYSTEMS

Understanding and Influencing Causality of Change

Overview

Understanding and influencing change is a central concern of design, commerce and societies. Well-intended interventions often lead to unexpected outcomes with significant implications for health, safety, security and prosperity. While considerable intellectual investment has been directed at quantitative and statistical approaches to understanding causality of change of socio-technical systems, the complexity and indeterminate nature of underlying states and often nonlinear dynamics of such systems pose significant, if not intractable, measurement, computational, and interpretation challenges. As a result, a scalable and functional understanding of underlying causal dynamics of socio-technical systems that can inform real-world interventions leading to desired outcomes remains elusive.

This book will address what is needed in order to close the gaps resulting from the limitations of current approaches. In particular, this book will summarize the fundamental underpinnings of complexity and causality in socio-technical systems. Using the resulting framework, this book will report on what can be learned about underlying causal dynamics from case-based successes and failures. This book will address the fundamental constraints and best options for coupling multiple approaches and methodologies to "capture" real world scope, scale and complexity of dynamic events. Also addressed will be the R&D options likely to push the states-of-the-art of understanding, prediction and intervention in terms of both control and design or re-design.

The book will be highly interdisciplinary, drawing upon history, economics, political science and philosophy; biology, physiology, zoology, anthropology, psychology, and sociology; and mathematics, physics, engineering, and computing. The level of exposition will be accessible by people from all these disciplines.

Part 1

: Introduction

Chap. 1: Introduction and Overview

- Introduction to the topic
- Summary of workshop findings
- Overview of book – one paragraph per chapter

Chap. 2: Fundamentals of Complexity and Complex Systems

- Theoretical constructs
- Implications for identification of root causes
- Anticipating higher-order effects
- Unintended consequences, for example:
    - Government farm price supports for corn lead to cheap low-quality calories which lead to obesity which leads to diabetes and heart disease which impose enormous healthcare cost burdens
    - Medicare price controls lead providers to over-charge patients with employer-based insurance which drives up employers' healthcare costs and depresses wages nationally

Chap. 3-5: Fundamentals of Causality

This chapter will address the question of how socio-technical systems evolve and transform in terms of the following questions:

- What are the dynamics of causality of change?
- What are the drivers and moderators to change and stability?
- What are the underlying causal dynamics that reflect and promote change and how do these vary with scale?
- How are causal dynamics determined by the nature of linkages and architectures of teams, groups, organizations, enterprises, and societies?
- What principles govern event propagation and emergence in socio-technical ecologies?
- What are the implications for design of interventions for transformation of organizations and enterprises in terms of emotions and attitudes, beliefs and ideologies, and cultures?
- To what extent can such interventions influence changes of individual, group, and organizational behaviors?

Chap. 6: Effects of Context

This chapter will address the influence of context on the nature of change, with emphasis on how context should be understood, addressed, and realized. Contrasts addressed will include:

- Public vs. private systems
- Products (e.g., airplanes) vs. service (e.g., healthcare)
- Domains, i.e., military, manufacturing, healthcare, power (Smart Grid), etc.

This chapter will also consider the roles of leadership, vision, and communication is affecting the causality of change.

Part 2: Methods & Tools

Chap. 7: State of the Art and Fundamental Challenges

This chapter will consider the state of the art and limits of current axiomatic, empirical and modeling methods and tools for characterizing, studying and understanding the etiology and dynamics of change in complex socio-technical systems. It will address the extent to which multiple approaches can be "viably" federated and/or made interoperable to support inferences about current, alternative or possible future states of complex socio-technical systems. This chapter, as well as chapters 8-16, encompass multiple sources of descriptive and prescriptive data from field work, stories, intelligence, models, surveys, ethnographic and case study analysis. This includes consideration of the best means for characterizing and understanding the influence of multi-factorial and/or bi-directional interacting causal chains.

Chap. 8-16

- Axiomatic Methods and Tools, e.g., like Newton or Einstein
- Empirical Methods and Tools, e.g., like Darwin or Mead
- Model-Based Methods and Tools

Part 3: Case Studies

Chap. 17: Introduction to Case Studies

This chapter will provide a framework for case-based approaches to the study of complex socio-technical systems. This will include consideration of case studies in the form of business school cases, accident and event investigations, and forensic social science. The chapter will address what can be learned about causal dynamics and managing complexity from successes and failures in real world interventions and practice.

Cases will be drawn from experiences in design, acquisition, human systems integration, problem solving/trouble shooting, medical practice, forensics, military "influence operations," risk analysis and assessment, marketing, technology forecasting, and organizational transformation.

Chap. 18-25: Case Studies

Part 4: Design and Intervention

Chap. 26: What Is Known

This chapter will address the extent to which current understanding and knowledge of causal dynamics and principal contributors can be used to influence desired outcomes in terms of control, design, and re-design.

Chap. 27: What Is Not Known

This chapter will summarize the gaps in concepts, principles, models, methods, and tools, including the prospects for filling these gaps. The possibility of Heisenberg-like uncertainty principles and Gödel-like incompleteness theorems will be considered.